



ORIGINAL ARTICLE

Demystifying Infection Prevention Strategy by Disposable Surgical Instruments

Rahul Saxena,^{1,*} Vivek Kumar Pathak,² Devendra Kumar Singh,³ Suyash Saxena⁴ and Ajit Pal Singh⁵

¹*Professor, Department of Biochemistry, School of Allied Health Sciences, Sharda Hospital, Sharda University, Greater Noida 201306 (UP), India*

²*Associate Professor, Department of Otorhinolaryngology, School of Medical Sciences & Research, Sharda Hospital, Sharda University, Greater Noida 201306 (UP), India.*

³*Professor & Head, Department of Respiratory Medicine, School of Medical Sciences and Research, Sharda Hospital, Sharda University, Greater Noida 201306 (UP), India*

⁴*Associate Professor, Department of Biochemistry, School of Allied Health Sciences, Sharda Hospital, Sharda University, Greater Noida 201306 (UP), India*

⁵*Associate Professor, Department of Medical Lab Technology, School of Medical and Allied Sciences, Galgotias University, Greater Noida, U.P. India, 203201.*

Accepted: 13-November-2025 / Published Online: 5-January-2026

Abstract

Background: Sepsis, a merciless curse and life-threatening silent storm caused by the body's response to an infection, remains a major complication following surgery. A wide range of infectious challenges can induce sepsis including surgical site infection. Moreover, during the surgery of patient suffering from infectious diseases, chances of cross infection are high. It is conceivable that three-dimensional (3D) printing technology has a significant role in limiting the chances of infection via development of advance surgical instrument. **Aim:** The objective of present study was to develop an effective preventive approach using 3D printing technology against nosocomial infection in a cost-effective manner which can be easily used in rural and urban areas as well. **Methodology:** Design of advance surgical instruments was created and functional prototype was developed by using PR 700 ABS equivalent material via 3D printing. **Result:** Six functional advance surgical instruments were developed, tested and feedback was taken from surgeon. These surgical instruments have enhanced functionality, efficiency, safety and cost effectiveness and can facilitate the surgeons in performing the surgeries with more accuracy and efficiency. **Conclusion:** Thus, the use of 3D printing technology in the development of advance surgical instruments has the potential to cause a paradigm shift in the management of sepsis, shifting away from supportive care and toward proactive and preventive measures to reestablish healthy and safe surgical conditions.

Keywords: Sepsis, nosocomial infection, Advanced Surgical Devices, pathophysiological tests

*Corresponding Author: Rahul Saxena
Email: rahul.saxena@sharda.ac.in

Graphical Abstract

Demystifying infection prevention strategy by disposable surgical instruments

Rahul Saxena^{1*}, Vivek Kumar Pathak², Devendra Kumar Singh³, Suyash Saxena⁴, Ajit Pal Singh⁵
Sharda Hospital, SMSR, SAHS, Sharda University & Galgotias University

Background: During the surgery of patient suffering from infectious diseases, chances of cross infection are high. It is conceivable that three-dimensional (3D) printing technology has a significant role in limiting the chances of infection via development of advance surgical instrument.

Developed prototypes of advance surgical instruments

S.No.	Instrument name	Status (Prototype developed at TRII stage 7 level and tested)
1	Side knife with reusable Camala (PR Application no. 202211003359)	
2	Circular knife with reusable Camala (PR no. 202211004418)	
3	Advance Needle Holder (PR no. 202211021315)	
4	Advance sponge holder (PR no. 202213076875)	
5	Advance Towel clip (PR no. 202211038130)	
6	Advance surgical scissor (PR no. 202211021314)	

Aims & Objectives
To develop an effective preventive approach using 3D printing technology against nosocomial infection in a cost-effective manner which can be easily used in rural and urban areas as well.

Material & Methods:
Design of advance surgical instruments was created and functional prototype was developed by using PR 700 ABS equivalent material via 3D printing. The data collected from surgeons via Likert scale ranking were entered manually and statistically calculated by using online graphpad software.

Conclusions: Thus, the use of 3D printing technology in the development of advance surgical instruments has the potential to cause a paradigm shift in the management of sepsis, shifting away from supportive care and toward proactive and preventive measures to reestablish healthy and safe surgical conditions.



National Board of Examinations
Journal of Medical Sciences

Introduction

Sepsis, a well-defined condition, occurs when severe infections exceed the immune system's usual regulatory systems, leading to a dysregulated host response that manifests as new-onset organ failure [1]. Patients undergo surgery are at increased risk of developing surgical site infection (SSIs) and should receive antibiotic prophylaxis [2]. Despite use of antibiotic as preprocedural treatment, SSIs occurs and the patients have to bear the additional pain in terms of cost of various biochemical and pathological tests, antibiotic prophylaxis, hospitalizations and repeated nosocomial infection in Post-COVID era. Recently, it has been documented that excessive use of antibiotics is associated with increased mortality and morbidities [3]. In urban areas, hospitals are well equipped with sterilization procedures but in rural areas various basic facilities and proper sterilization procedures are lacking.

Moreover, disposable version along with advance feature of surgical instruments are also not available to prevent infection while surgeries of patients with STDs and other infectious diseases like AIDS, COVID-19 etc. in urban and rural areas as well.

The use of surgical instruments in a clinical setting has been transformed by three-dimensional (3D) printing technology. Historically, all surgical procedures, including those involving patients with infectious diseases, have been performed by surgeons using traditional surgical instruments. Over the last few decades, advances in additive manufacturing technology have made it possible for medical science to progress to a more advanced level, leading to the development of innovative surgical instruments that can reduce the risk of nosocomial infections during surgery [4]. Therefore, the objective was to prepare the prototype of advanced disposable surgical

instruments kit by 3D printing technology which will be more economical, user friendly and can be tested in the real world of micro ear surgery.

Methodology

Design of the basic surgical instruments was conceptualized. PR 700 ABS equivalent material was used to prepare the instruments as per ASTM & ISO standards via 3D printing technology by vacuum casting [5]. Properties of material were tested in ISO certified laboratory with respect to Tensile strength, tensile modulus, shore hardness, elongation at yield and elongation at break. Developed sterilized prototype was clinically tested by surgeon after taking Ethical clearance (Ref. no. SU/SMSR/76-A/2024/28) from Institutional Ethical Committee of Sharda University. Data pertaining to various facts related to the developed prototypes of surgical instruments such as design and shape; size, user friendly, functionality, safety in surgery, compactness and time saving, were collected through feedback form from the surgeons (n=40) of various hospitals.

Statistical analysis

The data collected from surgeons via Likert scale ranking were entered

separately in Microsoft Excel sheet of windows 2007 and values were expressed as Mean \pm SD. In addition, correlation analysis between enhanced functionality and time saving feature was performed by using Pearson correlation test.

Results

Six advance surgical instruments were developed by using 3D printing technology and included these basic surgical instruments in a kit. These instruments were Side knife with inbuilt canula, Circular knife with canula, Advance surgical sponge holder, Advance surgical needle holder, Advance towel clip, and Advance surgical scissor. Information about developed prototypes of advance surgical instruments and their current status are illustrated in Figure 1. Feedback from surgeons were taken in relation to enhanced functionality, user friendly, effectiveness and time saving were observed. The result of feedback collected from various surgeons on numerous facts related to the developed prototypes of the surgical instruments was depicted in Figure 2. It was observed that these surgical instrument prototypes were excellent in design and shape; size, user friendly, functionality, safety in surgery, compactness and time saving.

S.No	Instrument name	Status (Prototype developed at TRL stage 7 level and tested)
1	Side knife with inbuilt Canula IPR Application no. 202211003359)	
2	Circular knife with inbuilt Canula (IPR no. 202211004418)	
3	Advance Needle Holder (IPR no. 202211021315)	
4	Advance sponge holder (IPR no. 202213076875)	
5	Advance Towel clip (IPR no. 202211058130)	



Figure 1. Developed prototypes of advance surgical instruments and their current status

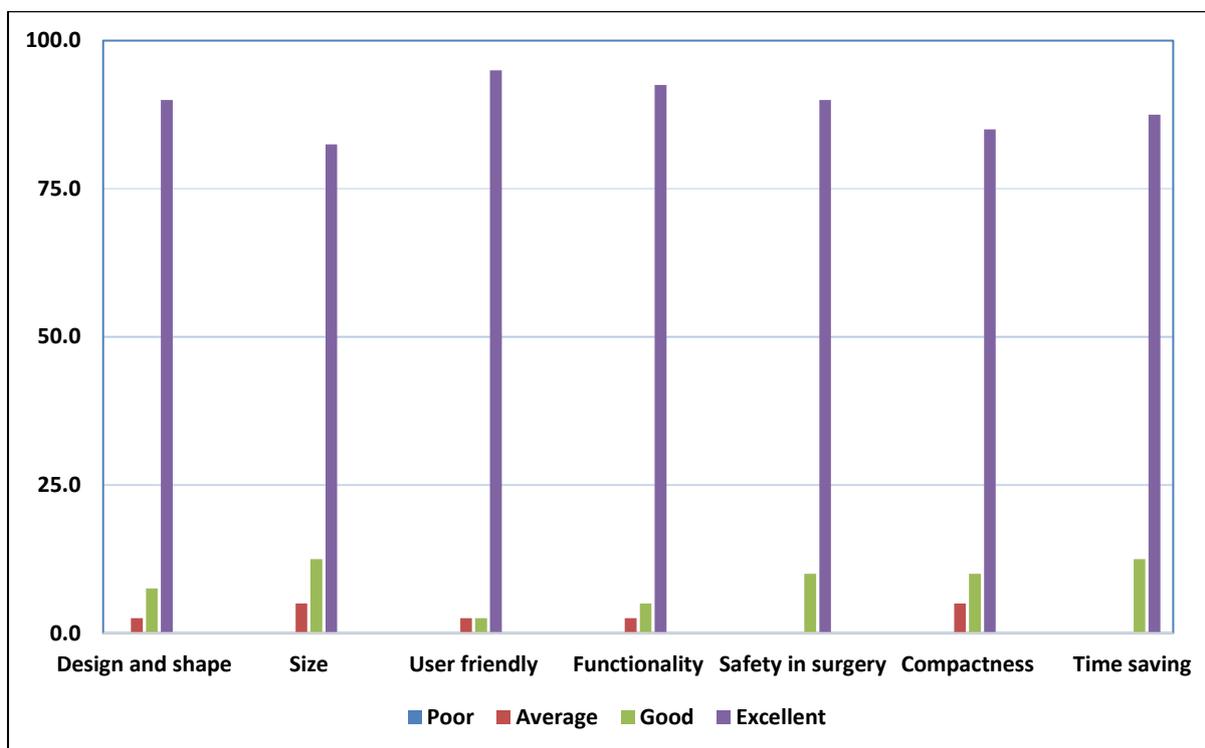


Figure 2. Feed back from various surgeons on various facts related to the developed prototypes

The material used in the preparation of these prototypes were tested in ISO certified laboratory and report was represented in Table 1. On applying correlation coefficient, it was observed that enhanced functionality and time saving feature were direct related to each other ($r=0.648$; $p<0.001$) as represented in Figure 3. In addition, patent of all the six instruments were granted (IPR Application

no. 202211004418; 202211021314; 202211021315; 202211003359; 202213076875; 202211058130) [6]. Product of these prototypes in multiple copies can be developed and commercialized through surgical agencies. These advance surgical instruments are safe and cost effective which can be distributed to the rural areas under community services.

Table 1. Lab report for material (PR 700 ABS Equivalent) used in the prototype development

S. No.	Parameter	Unit	Test method	Test Result
1	Average Tensile Strength	N/mm ²	As Per UTM Machine	55.23.0
2	Tensile Modulus	Mpa	ISO :527-1	1670.0
3	Shore Hardness	Shore D	Hardness Taster	80.0
4	Elongation At Yield	%	As Per UTM Machine	2.20
5	Elongation At Break	%	As Per UTM Machine	7.34

UTM: Universal testing machine

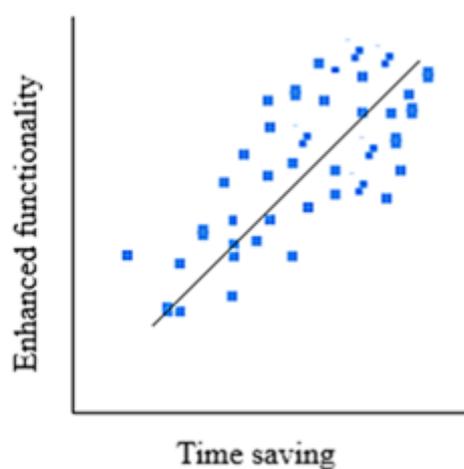


Figure 3. Enhanced functionality and time saving feature of the developed prototypes.

Discussion

There are various strategies to overcome the problem of sepsis. However, this curse of SSI still exists and have a wider room space to encourage the researchers to replenish the safe and healthy surgical procedures with some concrete solution. So, to solve the problem in the real world of micro-ear surgery in rural areas, there is a dire need to incorporate advance features to increase the functionality, safety, efficiency, and cost effectiveness of the instruments; and to help the surgeons in performing the surgeries with more accuracy and efficiency. In this context, the role of 3D printing technology paves a novel path in the field of medical sciences including surgery [7]. Interestingly, Parab et al. in their investigation also stressed that in order to reach the middle ear's nooks and corners without impairing vision and causing instrument cross-over, a modified circular knife is necessary [8]. Consequently, the prototype of six surgical instruments: Side knife with inbuilt canula, Circular knife with canula, Advance surgical sponge holder, Advance surgical needle holder, Advance towel clip, and Advance surgical scissor; have been prepared using 3D printing technology.

These advance surgical instruments can help in the following ways to the surgeons:

- More efficient and time saving instrument are available for the surgery.
- Multiple instruments can be used by surgeons in more flexible manner
- Different size number of suction cannula/ knife can be easily fitted in the same instrument so it can reduce the requirement of various separate

instruments.

- The sliding feature in the handle of needle holder, sponge holder and towel clip can allow the surgeon to fix the shank of the surgical instrument as per need and **adjust the length** of these surgical instruments to reach deeper areas of nasopharyngeal region and decrease the height when front areas are to be reached.
- The multiple locking system along locking ratchet provides the complete **stability** while working.
- The disposable feature helps the surgeon to use it only one time with patient suffering from sexually transmitted disease or infectious diseases. It can reduce the chances of infection effectively and economically.
- The present instruments allow the use of **same instrument** in different types of surgeries where different length of needle holders and sponge holders are required and thus, making the instrument **economically**.
- In addition, these advance and basic instruments (except side/circular knife) can be used in the surgery related to other field of medical sciences such as respiratory medicine, gynecology, general surgery and dental science also.

Conclusion

Thus, these 3D printed technology mediated developed surgical devices can contribute significantly in the reduction of nosocomial infection rates, improving patient outcomes, and reducing healthcare costs associated with sepsis treatment. Furthermore, the present study explores the future directions of advanced surgical devices, limited use of antibiotic &

pathophysiological tests and preventive-healthcare measures in the ongoing fight against sepsis mediated pain of the patient.

Limitation

The present surgical instruments were tested in Sharda Hospital only by ENT surgeon due to constraints of resources. We plan to do Multicentric study is needed to get more feedback in order to improve the efficiency of the instrument from patient and surgeon perspective.

Conflicts of interest

The authors declare that they do not have conflict of interest.

Funding

This work was supported by the National Research Development corporation (NRDC), New Delhi (NRDC-HQ/ NRDC-HQ/220005/TCS/2022-23) and Intramural Research Grant, Sharda University.

References

1. Victorsson SA, Turnbull IR. Sepsis in surgical patients: Personalized medicine in the future treatment of sepsis Surgery. 2024;1-3 doi: 10.1016/j.surg.2024.03.042
2. Napoli F, Aleman R, Zadneulitca N, et al. Sepsis in cardiothoracic surgery. Surgery. 2023;175(2):556-558. <https://doi.org/10.1016/j.surg.2023.10.015>
3. Shi W, Chen Z, Shi L, et al. Early antibiotic exposure and bronchopulmonary dysplasia in very preterm infants at low risk of early-onset sepsis. JAMA Netw Open. 2024;7(6):e2418831. doi:10.1001/jamanetworkopen.2024.18831.
4. <https://www.precise3dm.com/figure-4-pro-blk10.php>
5. Things to Know about Likert Scales – MeasuringU
6. <https://iprsearch.ipindia.gov.in/PublicSearch/PublicationSearch/ApplicationStatus>
7. Mehrzad R, Denour E, Crozier J, Woo A S. The Use of In-House Patient-Specific 3D Printed Models in Plastic-, Orthopedic and Neurosurgical Planning: A Preliminary Report. Journal of 3D Printing in Medicine. 2023;7(4). <https://doi.org/10.2217/3dp-2023-0009>
8. Parab, S.R., Khan, M.M., Memon, R.A. et al. Modified Circular Knife in Two-Handed Endoscopic Ear Surgery: A Technical Note. Indian J Otolaryngol Head Neck Surg 2024;76:3726–3729. <https://doi.org/10.1007/s12070-024-04725-5>.